lution. This line is vertical in the realisation now to be given, and it or any line parallel to it will be called vertical in the drawing, and any line perpendicular to it will be called horizontal. The distance between any two horizontal lines in the drawing will be called *difference of levels*.

Through any point, N, of the axis draw a line, N P, cutting it at any angle. With any point, O, as centre on the line N P, describe a very small circular arc through P P′, and let N′ be the point in which the line of O P′ cuts the axis. Measure N P, N′ P′, and the difference of levels between P and P′. Denoting this last by δ, and taking a as a linear parameter, calculate the value of

$$\left(\frac{\delta}{a^2}+\frac{1}{\mathrm{OP}}+\frac{1}{\mathrm{NP}}-\frac{1}{\mathrm{N'P'}}\right)^{-1}.$$

Take this length on the compasses, and putting the pencil point at P′, place the other point at O′ on the line P′ N′, and with O′ as centre, describe a small arc, P′ P″. Continue the process according to the same rule, and the successive very small arcs so drawn will constitute a curved line, which is the generating line of the surface of revolution inclosing the liquid, according to the conditions of the special case treated.

This method of solving the capillary equation for surfaces of revolution remained unused for fifteen or twenty years, until in 1874 I placed it in the hands of Mr. John Perry (now Professor of Mechanics at the City and Guilds Institute), who was then attending the Natural Philosophy Laboratory of Glasgow University. He worked out the problem with great perseverance and ability, and the result of his labours was a series of skilfully executed drawings representing a large variety of cases of the capillary surfaces of revolution. These drawings, which are most instructive and valuable, I have not yet been able to prepare for publication, but the most characteristic of them have been reproduced on an enlarged scale, and are now on the screen before you.[1] Three of the diagrams, those to which I am now pointing (Figs. 10, 11, and 12), illustrate strictly theoretical solutions—that is to say, the curves there shown do not represent real capillary surfaces—but these mathematical extensions of the problem, while most interesting and instructive, are such as cannot be adequately treated in the time now at my disposal.

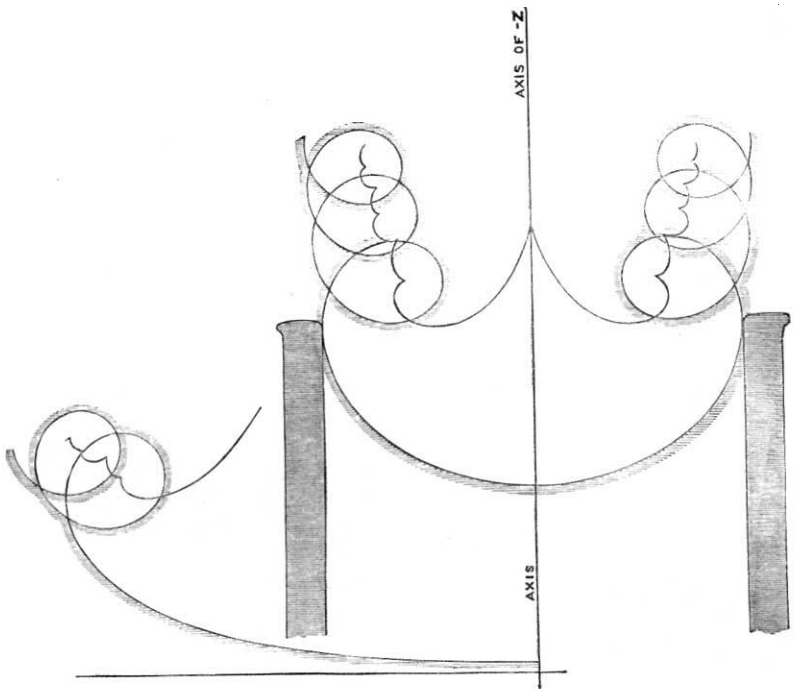

FIG. 12.

WILLIAM THOMSON

(*To be continued.*)

THE SCIENCE AND ART DEPARTMENT EXAMINATION IN CHEMISTRY

THE new editor of the "Science and Art Directory" announces a new departure of the most important kind in the teaching of chemistry. In addition to the oral instruction in the elementary stage, there is now introduced an alternative first stage or elementary course intended for those students who only require the elements of chemistry as a foundation for their studies in other subjects.

We give the new syllabus so that it may speak for itself, and congratulate the Department on a step in harmony with the views of the best friends of scientific education in this country.

SOLUTION.—Disappearance of a solid in a liquid by solution. Saturation of a liquid. Effect of increase of temperature on saturation. Effect of lowering the temperature on saturation. Crystallisation. Filtration. Solvent properties of water. Rain, spring, river, and pond waters, &c. Solid matter in different waters; how estimated. Loch Katrine water. Thames water. Sea water. Hard and soft waters. Mineral waters. Similar solvent of other liquids. Solution of one liquid in another. Liquids insoluble in one another. Solution of gases in water and other liquids. The effect of heat on the quantity of gas dissolved by a liquid.

Experiments.—Suspend a piece of white sugar by a thread in a glass vessel containing water. Dissolve salt in water. Show on a balance that sugar or salt and water when separate and when dissolved weigh the same. Show that salt is obtained

[1] The diagrams here referred to are now published in Figs. 10 to 24 of the present report of the lecture at the Royal Institution. These figures are accurate copies of Mr. Perry's original drawings, and I desire to acknowledge the great care and attention which Mr. Cooper, engraver to NATURE, has given to the work.

from the solution by evaporation. Saturate water with nitre, and show that the solubility is increased by increase of temperature. Demonstrate the formation of crystals. Illustrate the removal of substances in suspension, and the non-removal of substances in solution by filtration. Show by evaporation the solid matter dissolved in a sample of pump, or river, or spring water, and explain the method for its quantitative determination. Show the like solvent action with other liquids, as calcium chloride, in alcohol and sulphur in carbon disulphide. Compare the result of admixture of spirit or oil of vitriol with water with that of oil or mercury with water. Heat ordinary water and collect the expelled air.

AIR.—Surrounds the globe. Wind is air in motion. Breathing. Air occupies space. The bulk of any quantity of air is much changed by temperature and by pressure. Air has weight. The necessity of air for animals and plants. Bodies when burning require air. Air a mixture of two gases. Oxygen and nitrogen. The proportion of nitrogen to oxygen. Oxygen the active body in air. Bodies burn in it alone and more brilliantly than in air. The combination of oxygen with iron and with other bodies. Increase of weight of bodies which unite with oxygen. Nitrogen does not combine directly with bodies. The nearly constant composition of pure air. Presence of other gases in small amount in air. Water in the air as a gas. The drying up of water.

Experiments.—That air occupies space may be shown by plunging a bell jar into a vessel of water. Fit a flask containing water with an india-rubber plug and delivery tube, heat the water, and collect the expelled air over water. Close the short limb of a syphon tube containing air, and compress the air in the long limb by pouring in mercury. Weigh a flask, fitted with a stop-cock, full of air, and then exhaust by an air-pump, and weigh again. Show that a lighted candle is soon extinguished when burnt under a bell jar, but that it continues to burn if fresh air be from time to time supplied. Burn phosphorus in a tall bell jar over water, and show the diminution of bulk of air. Ignite phosphorus, place it in the remaining gas. Burn some phosphorus under a dry bell jar to show the compound of phosphorus and oxygen which is formed. Place phosphorus in a graduated tube over water to show that at ordinary temperatures it combines with the oxygen of the air and removes it, so that by measuring the volume of gas left, the amount of oxygen contained in air can be roughly determined (to introduce the phosphorus, fuse it in a test-tube under water, and introduce the end of a long wire into it, then let it cool). Burn charcoal and sulphur in oxygen, and call attention to their disappearance. Demonstrate by lime water and by litmus paper that a new body is in each case formed. Burn iron powder (*Ferrum vidactum*) on a scale pan of a balance, to show that an increase of weight occurs. A glass or metal vessel filled with ice or cold water can be used to show the condensation of mixture upon it. Place calcium chloride on the pan of a balance to show the gradual increase of weight which occurs.

WATER.—Its three states. Expansion of water by heat. Equal volumes at different temperatures have not the same weight. Formation of currents in water by heating. Boiling point. Increase of volume on conversion of water into steam. Distillation. Pure water. Hydrogen and its properties. The burning of hydrogen in air, and the weight of the product compared with the weight of the hydrogen; the difference due to oxygen of the air with which hydrogen has combined. Hence oxygen and hydrogen are the constituents of water. Combination of oxygen and hydrogen with explosion to form water. If by measure there be twice as much hydrogen as oxygen, or by weight eight times as much oxygen as hydrogen, then no gas remains—all becomes water. All water composed of these two bodies in this proportion. These two bodies can then be separated from water and can be made to make, unite, and form water. In all cases of chemical combination bodies are united in constant proportion.

Experiments.—Illustrate the characteristic properties of ice, water, and steam. Show that equal volumes of hot and cold water do not counterbalance one another. Fill a flask to the bottom of the neck with cold water, and then heat to show expansion of the water. Show current by heating a large flask of water. To illustrate distillation, distil water containing copper sulphate. Show Liebig's or other forms of condensers. Show the mode of determining the boiling point of a liquid. Show that the temperature remains constant, and that on dissolving substances in water the boiling point is raised. To show the presence of hydrogen in water, pass steam through a red-hot iron tube filled with coarse iron turnings or nails. Water formed of two components, both gaseous. Note the change in the iron both in appearance and weight. This increase of weight and the weight of gas which comes off equals weight of steam which has disappeared. Hence two substances in water, one the combustible gas that comes through the tube, the other the body which remains with the iron. Collect the hydrogen over cold water in proof that it is not steam, also show that it burns. After the tube is cooled show the iron from inside of the tube and explode the oxygen and hydrogen. Plunge a burning taper into jar of hydro en held mouth downwards, to show burning of the gas and extinction of the taper. Show by a balloon, or soap bubbles, or inverted beaker glass suspended from a balance, that hydrogen is lighter than air. Condense the water formed by the burning of a jet of hydrogen.

Carbon.—Charcoal, graphite, or blacklead and diamond. When wood, sugar, meat, bread are heated carbon remains. Charcoal not changed in the air at ordinary temperatures. Combination of carbon with the oxygen of the air at a red heat. Carbon dioxide a compound of carbon and oxygen. Chemical combination of carbon and oxygen is attended by the evolution of a definite amount of heat expressed by amount of water it will heat. Combustion. The properties of carbon dioxide. Water dissolves carbon dioxide at ordinary temperatures. Action of carbon dioxide on lime-water; no animal can live in this gas. 100 parts of carbon dioxide are composed of 27·27 parts of carbon, and 72·73 parts of oxygen. Carbon dioxide obtained from marble, limestone, oyster-shells, chalk, &c. Charcoal fire. Coal composed of carbon, hydrogen, and a little oxygen, &c.; its burning is the carbon and the hydrogen combining with oxygen. Whenever oil, tallow, coal gas are burnt this carbon dioxide and oxide of hydrogen (water) are formed. Respiration produces similar changes. In expired air the same products arise as from the burning of the food, and there is the same evolution of heat. Carbon a constituent of all animal and vegetable bodies.

Experiments.—Specimens of charcoal. Make charcoal by heating wood in covered crucible. The black lead of a pencil as a specimen of graphite. Sugar heated on piece of tin plate. Show that acids and alkalies do not change charcoal, but that when heated it soon burns away, and only ash is left. Take a small piece of charcoal in a glass tube, pass air over it into lime water, and show no change takes place until the charcoal is made red hot; as the charcoal disappears the lime water becomes milky. Show by means of the balance, or by soap bubbles, or by passing it from one vessel to another, that carbon dioxide is heavier than air, that it acts on lime water, that a burning candle is extinguished in it. Its solubility in water shown by agitating a tube of the gas over water. Prepare the gas from marble by the action on it of dilute acid. Collect all the gas given off from a small piece of marble weighing 5 or 10 grains. Show by collecting in inverted beaker the products of combustion of a candle, of a lamp, and of a gas flame, and adding lime water, that carbon dioxide is given off. Show also by means of lime water that respired air contains this gas.

SULPHUR.—Known also as brimstone. Where found. Its properties. Is also found chemically combined with many metals, so not recognisable by the eye. Sulphur heated in the air melts; more strongly heated it burns, then the sulphur disappears; the strong smell produced belongs to a new body formed by the burning, a compound of sulphur and oxygen. Gaseous properties of the new body, its effect on blue litmus paper, which oxygen and sulphur have not. Its composition is 50·00 parts of sulphur and 50·00 parts of oxygen, and it is called sulphur dioxide. Water dissolves nearly fifty times its volume of this gas, and then turns blue litmus strongly red and has an acid taste. The combination of the gas and water to form sulphurous acid. Another compound of sulphur and oxygen can be made, in which the same weight of sulphur is combined with more oxygen. One hundred parts contain 40 of sulphur and 60 of oxygen, and it is called sulphur trioxide. Sulphur trioxide has properties differing from the dioxide. If the dioxide and oxygen be mixed they do not combine, but if they are passed over hot platinum dense white fumes are formed, which are the trioxide. Combination of the trioxide with water to form sulphuric acid (oil of vitriol).

Experiments.—Show roll and flowers of sulphur and specimen of native sulphur, also iron pyrites and other native sulphides. Powder iron pyrites and heat it in a tube held horizontally over a lamp to show the sulphur obtained from the pyrites. Show the

melting of sulphur by heating flowers of sulphur in small flask. Heat sulphur on a piece of tin plate till it catches fire, show the colour of the flame and observe the smell of burning sulphur. Prepare sulphur dioxide by heating copper turnings in sulphuric acid, and show that it extinguishes flame, is very soluble in water, and that the water dissolving it becomes very acid, turning blue litmus red. Bubble air through a strong solution of sulphur dioxide, and then over platinised asbestos; demonstrate that when the platinised asbestos is hot dense white fumes are formed of the sulphur trioxide. Pour some sulphuric acid into 20 or 30 times its volume of water and prove its acid taste, its action on litmus, and its power of causing effervescence if dropped on sodium carbonate. Show that sulphuric acid is a colourless liquid, that bulk for bulk it is much heavier, more than $1\frac{3}{4}$ times, than water. Show by a thermometer or by immersing a test tube with spirit in it that a large amount of heat is evolved when this acid is poured into water. Pour some on sugar or shake it up with oil to show its action on organic bodies.

CHLORINE.—The gas obtained by the action of hydrochloric acid on the black oxide of manganese. So called on account of its colour. Its characteristic smell. Is $2\frac{1}{2}$ times heavier than air and $35\frac{1}{2}$ times heavier than hydrogen. Soluble in water. Many substances take fire in chlorine gas, *e.g.*, phosphorus, and form chlorides. Ignition of oil of turpentine in chlorine with separation of carbon and formation of hydrochloric acid. Bleaching power of chlorine. Bleaching-powder.

Experiments.—Samples of common salt, rock-salt. Prepare chlorine from (1) mixture of common salt, black oxide of manganese and sulphuric acid; (2) from mixture of black oxide of manganese and hydrochloric acid. Collect gas by downward displacement. Draw attention to its colour, and show that phosphorus spontaneously inflames in the gas to form chemical compound of phosphorus and chlorine. Show that oil of turpentine ignites spontaneously in chlorine. Show that sodium when strongly heated burns in chlorine and forms common salt. Show bleaching action of chlorine by dipping moistened Turkey red rag in bottle filled with gas. Show similar action with solution of bleaching-powder and acid. Show that chlorine is soluble in water and that the solution has characteristic smell and colour of the gas.

ACIDS.—Are bodies which have sour taste, turn blue litmus red, and liberate carbon dioxide when added to solution of sodium carbonate. Sulphuric acid has these properties. Its specific gravity. Colourless when pure. Evolves heat on being mixed with water. There are two other common bodies which have strong acid properties like sulphuric acid, these are nitric acid and hydrochloric or muriatic acid; these are made of different constituents from sulphuric acid. All act on litmus, &c. in same way; all can be neutralised by potash forming potassium sulphate, or nitrate, or chloride. The compound formed by the union of an acid and alkali is called a salt. All three acids are colourless liquids, but, beside the properties possessed by all acids, each acid has properties which belong to it alone. Nitric acid attacks most metals. Poured on copper the metal is dissolved and red fumes are formed. Hydrochloric acid does not dissolve copper, is not so heavy as sulphuric acid; when mixed with manganese dioxide gives off a yellow irrespirable gas known as chlorine.

Experiments.—Samples of both nitric and hydrochloric acid. Show that they have all the properties belonging to acids and that by neutralising them common salt and nitre can be made. Show the action of nitric acid on copper, tin foil, &c. Show that it has no action on platinum or on gold. Copper placed in hydrochloric acid not attacked, but if mixed with manganese dioxide and warmed chlorine is given off.

ALKALIES.—Are another class of bodies which turn red litmus blue; have soapy taste and absorb carbon dioxide. If potash be added gradually to sulphuric acid the properties of both bodies gradually disappear, and at last a liquid is obtained that has no action on litmus. The combination of acid and alkali and the body formation of sulphate of potash or potassium sulphate; sulphate of soda or sulphate of ammonia can be formed in a similar manner.

Experiments.—Show that solutions of potash, soda, and ammonia turn reddened litmus blue, and that when a tube containing carbon dioxide is inverted in any of these solutions the gas is absorbed. The taste of these bodies is soapy not sour. Add gradually to dilute sulphuric acid one of these bodies, and see that the acid character of the dilute sulphuric acid disappears. Neutralise exactly sulphuric acid with potash, then evaporate and crystallise out the salt formed.

AMMONIA.—A gas with a very pungent smell. Solution in water. One volume of water dissolves 800 volumes of ammonia. This liquid has the pungent smell of the gas, and it can neutralise the strongest acids. Formation of ammonium chloride or sal ammoniac by ammonia with hydrochloric acid. Ammonium chloride a white solid, soluble in water, with no smell of ammonia. Ammonium chloride a volatile body. The effect of boiling a solution of ammonium chloride with lime or potash. Ammonia is composed of 82·3 parts of nitrogen and 17·7 parts of hydrogen. The pungent odour of smelling salts is due to ammonia. Animal matters, such as horn, dried flesh, glue, cheese, isinglass, heated so as to decompose these bodies, yield ammonia. The formation of ammonia in large quantities by heating coal to make coal gas. Production of ammonia when animal matters containing nitrogen putrify.

Experiments.—Prepare ammonia by treating ammonium chloride with an equal weight of slaked lime and enough water to make the whole into a thick mud; and demonstrate its smell, its action on red litmus, and its great solubility in water. The gas passed into water, the increase of volume of the liquid. Its properties and their identity with those of the gas. Volatility of ammonia shown by the liquid leaving no residue on evaporation. Show that ammonium chloride is formed by neutralising a solution of ammonia with hydrochloric acid, and is obtained as a solid on evaporation, and that on further heating it is volatilised. Heat coal in a coarse powder in a glass tube, and show that the liquid obtained is very alkaline. Show the formation of ammonia by the addition of potash and lime to a solution of ammonium chloride.

LIME AND CLAY.—Limestone, marble, oyster-shells, chalk, all contain a metal known as calcium. The oxide of this metal known as lime. Lime and carbon dioxide are together present in limestone, marble, shells, and chalk. When these are strongly heated, especially in a current of air, the carbon dioxide is evolved and the lime is left. Action of water on lime. Its use in making mortar. Lime slightly soluble in water. On blowing carbon dioxide into a clear solution of lime (lime-water), liquid becomes turbid, owing to combination of carbon dioxide and lime to form chalk. Same effect on breathing through lime-water. Other important salts of lime are gypsum or plaster of Paris (sulphate of lime) and phosphate of lime, which exists largely in bone. Clay is a combination of a body called silica, which is the chief constituent of sand and flint, with the oxide of a metal known as aluminium, so called because it exists also in alum. Glass is a compound of silica with lime and an alkali, potash or soda. Varieties of clay; their use in manufacture of bricks and pots. The metal of clay (aluminium), a white body with a brilliant lustre, $2\frac{1}{2}$ times heavier than water; may be rolled out into thin sheets and drawn into fine wire. Not oxidised in the air.

Experiments.—Samples of limestone, marble, oyster shells. Show that these substances effervesce with dilute hydrochloric acid, and that a gas carbon dioxide is evolved. Heat a piece of limestone or marble to redness in a fire, and show that after heating it no longer gives off carbon dioxide on treatment with an acid. Describe process of lime-burning. Properties of lime as distinguished from limestone. Show that a piece of moistened red litmus paper pressed against limestone is not affected, but that when pressed against lime it is turned blue. Show slaking of lime; draw attention to heat evolved. No such result on treating limestone with water. Show that lime is soluble in water, whereas limestone is not. Add carbon dioxide to the solution of lime, and show that white powder is formed which on treatment with acid evolves carbon dioxide again. Explain that white powder thus formed is identical in chemical composition with limestone, and hence that limestone is a compound of carbon dioxide and lime. Explain use of lime in making mortar. Various samples of clay are used in manufacture of bricks and pots. Show plasticity of clay and exhibit one or two specimens of ware before being baked. Show that a vessel of kneaded or "puddled" clay will hold water. Explain chemical nature of clay, and show specimens of silica and alumina. Show alum and demonstrate that alumina is contained in it by heating ammonia alum. Show specimen of aluminium and explain that this metal is contained in alumina and therefore in clay.

METALS, INTRODUCTORY.—About 70 different elementary subjects known. Almost all the common metals are elements. For instance, iron, lead, copper, zinc, mercury, silver, gold, tin, are elements. All combine with oxygen to form oxides, with chlorine to form chlorides, and with sulphur to form sulphides.

Experiment.—Specimens of metallic and non-metallic elements and of oxides and sulphides.

LEAD.—Its colour; a fresh surface bright, but soon tarnishes in the air. Is heavy. Lead is $11\frac{1}{2}$ times heavier than water. Can be beaten or rolled into thin sheet or drawn into wire. Melts at temperature 633° F. Can be cast in a mould. Its combination when liquid with oxygen. Formation of lead oxide. The oxide has entirely different properties from lead. Removal of the oxygen when heated with carbon and the formation of metallic lead. Formation of red lead by heating the oxide. Solution of lead by nitric acid and the formation of lead nitrate. Solution of lead oxide by nitric acid and the formation of lead nitrate. Similarly to potassium nitrate this is to be termed "a salt." Its solution in water. Other salts of lead, chloride, sulphate. Formation of sulphate and chloride of lead, their insolubility in water. Galena, or lead sulphide, one of the ores from which lead is obtained.

Experiments.—Piece of lead to scrape and show it is then bright and has "metallic" appearance. Show by balance that compared with water it is bulk for bulk much heavier. Show the metal beaten out into thin sheet, also as wire. Melt lead in an iron spoon, and cast in a mould. Show formation of oxide by blowing air on to the melted metal. Contrast the properties of the oxide with those of the metal. Convert the oxide again into metal by strongly heating an intimate mixture of it and charcoal powder. Heat the oxide to show its further oxidation and the formation of red lead. Show the action of nitric acid on lead, also on lead oxide, and the formation of lead nitrate. Show this is "salt," and prove that it is soluble in water. Demonstrate that the first is very slightly soluble, and the last almost insoluble in water. Show the formation of chloride and sulphate of lead by the addition of the respective acids to a solution of lead nitrate. Collect on filter the salts so formed, wash and dry them. Show specimen of Galena (lead sulphide).

IRON.—Not used in a pure condition, always obtained united with carbon. Three kinds of iron; wrought iron, cast iron, and steel. Wrought iron the purest and used if the body is to be formed by hammering. Cast iron contains most carbon. Steel used for cutting instruments; can be made into a magnet; can be "annealed." Solubility of all three forms of iron in sulphuric, nitric, and in hydrochloric acids, and the formation of iron sulphate, nitrate, and chloride. Their solubility in water. Melting point of iron is at much higher temperature than that of lead. Comparison of the weight of iron with that of water. Its colour. The ready action of air on it. Formation of rust. Oxidation by heating. The action of steam on iron when red hot. Oxide of iron heated with hydrogen or with carbon parts with its oxygen, and iron is left. Oxide of iron found in the earth. Hæmatite. A carbonate of iron mixed with clay used as a source of iron. Heating the ore the iron is converted into oxide. Removal of the oxygen by heating it to a very high temperature with carbon. Formation of slag from clay and lime.

Experiments.—Specimens of the different kinds of iron, wrought iron, cast iron, and steel. Dissolve cast iron in hydrochloric acid diluted with equal volume of water, show carbon which remains, filter and evaporate the liquid to show the chloride of iron formed. Heat iron wire by the blowpipe to show the high temperature required to fuse it. Iron acted on by air and moisture to show its rusting. Heat iron oxide in a tube and pass hydrogen over it to show formation of water and metallic iron. Show specimens of iron ores, clay iron stone. Hæmatite magnetic iron ore, and slag.

COPPER.—Its colour. Does not rust in air at ordinary temperatures. Thin wire melts in flame of Bunsen burner. When heated in air becomes black, owing to formation of an oxide. Oxide heated in hydrogen gas yields up its oxygen, water is formed, and the red-coloured copper is obtained. Action of acids on copper. With dilute nitric acid evolves a colourless gas, which turns red in contact with the air, and the metal dissolves, forming a green solution of copper nitrate. Heated with sulphuric acid copper yields sulphur dioxide, the same gas which is formed when sulphur burns in air or in oxygen. Substance formed when copper dissolved in sulphuric acid is when crystallised from water of a fine blue colour, known as copper sulphate or blue vitriol. Action of vegetable acids on copper. Verdigris. Use of copper in alloys. A penny composed of 95 parts of copper, 4 parts of tin, and 1 part of zinc. Bell metal and gun metal contain copper and tin.

Experiments.—Show specimens of copper in bar, sheet, and wire. Point out characteristic colour of metal. Heat piece of sheet copper over flame of Bunsen burner. Show formation of black film. Explain its origin. Take black oxide of copper and heat in hydrogen gas. Show that metal is again formed and that water is produced. Show action of nitric and sulphuric acids upon copper. Exhibit specimen of copper sulphate (blue vitriol). Show that on placing a knife blade in a solution of copper sulphate metallic copper is formed on the steel. Show sample of verdigris and explain how formed. Show various alloys of copper, bell-metal; brass, gun-metal, &c., a penny-piece.

MERCURY.—A liquid metal, but if it be cooled to $-40°$ Fahrenheit it is solid. Its metallic appearance. Its weight; heaviest liquid known; 13·6 times heavier than water. Use in the barometer and thermometer. Does not rust or tarnish in the air at ordinary temperatures, oxidation if heated to about 600° F. in the air, and the formation of red mercuric oxide. Is readily attacked and dissolved by nitric acid. It dissolves many metals, —*e.g.*, tin, lead, &c.; amalgams. Mercury in combination with sulphur, as cinnabar. Mercury can be obtained from any salt of mercury by heat, volatilization of mercury, and the condensation of the vapour.

Experiments.—Specimen of mercury. Show that to balance a given volume of mercury $13\frac{1}{2}$ volumes of water are necessary. Boil a little mercury in a tube to show it vaporizes. Treat mercury with nitric acid and show its solution. Show that tin foil is dissolved by mercury, which becomes less fluid. Heat mercuric oxide in a tube and collect both the oxygen and the mercury. Heat mercuric chloride in tube sealed at one end with dry sodium carbonate and show the metallic mercury condensed on the side of the tube.

SODIUM.—Common salt contains a metal combined with chlorine known as sodium. 100 parts of common salt contain 39·3 parts of Sodium and 60·7 parts of Chlorine. Carbonate of soda (washing soda) contains sodium. Sodium obtained on strongly heating carbonate of soda with charcoal. Sodium one of the lightest solids known. Swims on the surface of water and decomposes that liquid with evolution of hydrogen and formation of the alkali soda. Other properties of the metal sodium: its low fusibility and softness. Its tarnishing in air. Preservation of sodium from action of air by being kept in same liquid lighter than water and free from oxygen.

Experiments.—Samples of common salt and rock salt; also washing soda and bicarbonate of soda. Recall experiment showing that chlorine is constituent of common salt. Show that washing soda and sodium bicarbonate evolve carbon dioxide on treatment with an acid. Common salt a compound of chlorine with a metal called sodium; bicarbonate of soda and washing soda compounds of carbon dioxide and sodium. Sodium can be made by strongly heating sodium carbonate with charcoal. Exhibit specimen of portions sodium. Show that it can be cut with a knife, and that the so cut can be pressed together again. Exhibit metallic lustre of sodium; show that it quickly tarnishes in the air. Show that sodium is lighter than water and decomposes that liquid with evolution of gas (hydrogen). Collect hydrogen from water by thrusting small piece of sodium beneath test-tube filled with water and standing in basin of water.

CARBON COMPOUNDS.—Large numbers of substances are met with in plants and animals which are not found in the earth. Most of these bodies contain carbon. The other elements united with the carbon are hydrogen, oxygen, nitrogen; some bodies are composed of all these elements; others of only two of them. Many of these bodies when heated leave black residue of carbon; when this is more strongly heated it burns away. The great number of these carbon compounds, and the great difference in their properties. Some are acids, *e.g.*, vinegar (acetic acid), and tartaric acid. Some are salts, *e.g.*, fats, tallow, butter. Some are neutral bodies, *e.g.*, sugar, starch, spirit.

Experiment.—Show that on heating any ordinary vegetable or animal substance carbon is left behind.

ACETIC ACID.—One form of dilute acetic acid is known as vinegar. Formation of acetic acid when beer or wine exposed to the air becomes sour. The spirit present combines with oxygen of the air and forms acetic acid. The presence of a kind of fungus called *mycoderma aceti* necessary to cause this oxidation. Large amount of vinegar is made from poor kinds of wine and beer. Action of vinegar on blue litmus, and on sodium carbonate. Vinegar is also made by heating wood in a retort; a great many bodies distil over, among them acetic acid. The pure acid has very pungent smell, and has all the properties which are characteristic of the acids. Boils at 246° F. Dissolves in water. It is composed of carbon, hydrogen, and oxygen in the proportion of 40·0 parts of carbon, 6·7 parts of hydrogen,

and 53·3 parts of oxygen. It is neutralised by alkalies like sulphuric acid. Iron put into it is slowly dissolved, hydrogen being given off. Oxide of lead dissolves in it, forming a salt, and if the clear solution be evaporated a white crystalline body called "sugar of lead" is formed, which is lead acetate. The vinegar smell belongs only to the acid, not to the salts. Sodium acetate has no smell; add to it sulphuric acid and warm, when the smell shows the acid has been liberated and that it is volatile.

Experiments.—Show that vinegar has the properties of an acid, and that a salt is formed on neutralising it. Show a specimen of the commercial acetic acid, and point out its colourless appearance and strong smell and acid reaction. Show that iron is acted on and dissolved by acetic acid. Make sugar of lead by dissolving lead oxide in acetic acid, and crystallise out the salt. Point out disappearance of the pungent odour of the acid on neutralisation by potash or soda. Demonstrate the liberation of the acid as indicated by the odour on addition of sulphuric acid to sodium acetate, and show that it can be separated from the liquid by distillation.

TARTARIC ACID.—Occurs in many fruits; especially in grapes. Is obtained from "argol," an impure potassium salt of tartaric acid, deposited when grape juice ferments. Tartaric acid is a crystalline solid, and dissolves easily in water. Has no smell. Is composed of carbon, hydrogen, and oxygen, *i.e.*, the same elements as are in acetic acid but in different proportions, viz.: 32·0 parts of carbon, 4·0 parts of hydrogen, and 64·0 parts of oxygen. Its action on sodium carbonate. Effervescing draughts; seidlitz powders. Tartrates.

Experiments.—Specimen of argol and of crystals of tartaric acid. Show solubility of the solid acid in water, and that the solution has acid properties and is without odour. Demonstrate the presence of carbon in the acid by ignition.

FAT AND OILS.—Are neutral bodies made up of an acid and a base, the base in all cases is glycerine, the acid varies in different oils and fats. They are all insoluble in water. Oils are liquid; fats are solid. Many of the oils are obtained from vegetables, either from the seed or fruit. Most of the fats are from animals. Melting of tallow (fat of the ox, sheep, &c.) put in boiling water. Its non-solution in water. Its lightness as compared with water. If a solution of caustic potash be added, and the solution of the liquid boiled, the fat disappears and the liquid becomes slightly milky, and nearly the whole dissolves. Combination of the potash with the acid (stearic) of the tallow and formation of potassium stearate. Previously the stearic acid was combined with glycerine. To the solution of potassium stearate hydrochloric acid is added. The potash is again separated from the stearic acid, and the stearic acid, as it cannot dissolve in water, separates out. Stearic acid dissolves in alcohol and in ether and separates out in crystals. Used in making candles, and is better than tallow because it melts at a higher temperature. Tallow distilled with steam of temperature 600° F. (high pressure steam) separates into stearic acid and glycerine, and when cold these bodies remain separate. All oils and fats are decomposed by potash in the same way as tallow.

Experiments.—Tie beef or mutton fat up in muslin bag, and melt to separate the fat from membranous matter. Show that fat is insoluble in water, that it floats on water, and melts at a temperature below boiling water. Show that oil has very similar properties to melted fat. Boil oil or fat with caustic potash. Prepare a solution of potassium stearate, and precipitate stearic acid from it by the addition of hydrochloric acid. Show the solubility of the acid in alcohol and ether, and the insolubility of the lime salt of stearic acid.

GLYCERINE.—A thick colourless liquid with a sweet taste. Dissolves readily in water. When quite pure becomes solid at a low temperature. If heated alone it is destroyed, but if heated with water in a retort it distils over with the steam. Heated with acids it combines with them, and bodies similar to fats are formed.

Experiment.—Specimen of glycerine. Demonstrate its solubility in water and its sweet taste.

SOAP.—By boiling fat with caustic soda sodium stearate is formed. On adding salt to the liquid the sodium stearate, which is soap, separates out and solidifies on the surface of the liquid. Soft soap is potassium stearate. Action of soap in washing. Action of soap on hard and on soft waters.

Experiment.—Shake distilled water up in bottle with soap. Show action of solution of salts and acids on the solution. Add soap solution to distilled water, also to common water, and explain the difference of action. Show the presence of stearic acid in soap by adding hydrochloric acid to a solution of soap.

SUGAR.—Exists in many plants. Is obtained from the sugar-cane; also from beetroot. The juice of these plants yields the sugar. When pure it is white, crystalline, sweet, and very soluble in water. Sugar candy. If heated with very little water to 365° F., on cooling it is no longer crystalline and is "barley sugar." Does not combine with acids, but even a very little acid boiled for a long time with a solution of sugar changes it to another kind of sugar. Composition of cane sugar. The several different kinds of sugar, *e.g.*, the solid part of honey is a sugar which differs from the sugar in the sugar-cane; the same found in all sweet fruits and is called grape-sugar. Grape-sugar not so sweet nor so soluble as cane-sugar.

Experiment.—Specimens of ordinary white and brown sugar; also sugar candy and barley sugar. Show its great solubility in water; also that its solution is neutral. Heat it and point out the peculiar odour it gives out, and that on further continuing the heat it leaves a residue of carbon. Wash honey with spirit, and show the residue is sugar, but that it is not sweet as ordinary sugar, and not so soluble.

STARCH.—A neutral substance, composed of carbon, hydrogen, and oxygen. Composition. Peculiar structure; not crystalline. Is found in all parts of a plant. Is obtained from wheat, rice, potatoes, arrowroot, &c. Starch in its ordinary condition insoluble in water. When starch powder is boiled with water, the membrane of starch cells bursts, and the starch is partially dissolved. Strong solutions form a jelly when cold. Used for stiffening linen. Starch recognised by its forming a blue compound with iodine. Undergoes no change in the air at ordinary temperatures; if heated to about 300° F. it becomes slightly discoloured and is changed into a soluble body, known as British gum (dextrin). If small amount of nitric or hydrochloric acid be added to the starch this change is more rapid. Extract of malt also changes starch into soluble compounds. Starch as a food.

Experiment.—Specimen (of starch), point out its peculiar structure and absence of crystalline form. Demonstrate that it does not dissolve in cold water, but on boiling some does dissolve. Show that starch both solid and in solution gives a blue colour when iodine is added to it. Moisten starch with very dilute hydrochloric acid, and heat to convert it into a gum, which is thus soluble in water.

GLUTEN.—If flour is tied up in a calico bag and well kneaded in a basin of water, the water becomes milky, and on standing starch sinks to the bottom. All the starch in the flour can thus be removed, and then a sticky substance remains in the bag called gluten. About 70 per cent. of flour is starch and 10 per cent. is gluten. Gluten contains nitrogen, starch does not. These bodies represent two most important constituents of food. The gluten exposed to the air soon decomposes and smells very disagreeably (putrifies).

Experiment.—Tie some flour up in a piece of calico and knead it for some time in a vessel of water; the starch comes through, and will settle to the bottom of the vessel, and can be collected and examined; the gluten remains in the bag.

SPIRIT.—Alcohol, spirits of wine. A colourless, light liquid. Neutral to test papers. Has pleasant odour, boils at 173° F. Burns with a flame, which gives very little light, without leaving any black residue of carbon. A large number of different bodies dissolve in it. It is the intoxicating principle in wines and spirits. In beer there is 3 to 5 per cent. of alcohol. In light wines about 8 per cent. In spirits 60 to 75 per cent. The different flavours of wines and spirits depend on very small quantities of other bodies present. Alcohol dissolves in water, giving out heat.

"Proof spirit" contains 50·76 parts of water, and 49·24 parts of alcohol. If more water be present the spirit will not set fire to gunpowder when burning. Alcohol obtained from grape sugar. Fermentation grape sugar converted into alcohol and carbon dioxide by presence of some ferment which exists in yeast. Cane sugar on the addition of yeast is first converted into grape sugar, then into alcohol and carbon dioxide. Use of yeast in brewing. Not necessary for making wine, as there is already a ferment in expressed juice of grape.

Experiment.—Show it is neutral liquid dissolving in water, that it burns with nearly colourless flame, and leaves no residue of carbon. Show that it can be made to boil at much lower temperature than water by placing test-tube of it in hot water. Distil beer and collect the alcohol and water which comes over;

add quicklime to this. Allow it to stand some hours, and distil again. Show that this is much stronger, catches fire readily, and tastes more burning. Make a solution of common sugar in a large flask; add yeast, and fit a cork with a bent tube to the flask. Let the tube dip into lime water. Place it in a warm place, and after some days show that spirit has been formed in the flask by distilling the liquid and collecting the portion coming over first.

All the substances and experiments mentioned above are to be shown to the class. This does not preclude such other experiments and illustrations as may suggest themselves to the teacher.

NOTES

WE trust that it is not in the least likely that the proposal "From a Correspondent" in Saturday's *Times* to remove the Science Museum to make way for a permanent Colonial Museum will receive serious attention in any influential quarter. For this proposal really involves the monstrous step of shunting collections which have been brought together with so much trouble and at so much expense. Their value was recognised by the Duke of Devonshire's Commission. As to the Colonial Museum we shall be in a better position to express an opinion upon it when its nature and objects are further developed. We wish in no way to disparage it; but there is room for it elsewhere. Why should its founders try to build it on the ruins of an existing and valuable collection?

THE thirty-fifth meeting of the American Association for the Advancement of Science will be held at Buffalo, from Wednesday, August 18, until Tuesday evening, August 24, 1886. For the third time, at intervals of ten years each, the Association has accepted an invitation to hold a meeting in Buffalo. The Local Committee intend to make the meeting a great success: and members who were at the meeting of 1876 need only to recall it in order to form an idea of what the coming meeting promises to be. The facilities which the city offers are all that can be desired, both in regard to rooms for the several Sections and in hotel accommodation, while the health and comfort of the city in the month of August are well known. The headquarters of the Association will be at the High School, and all the offices and meeting-rooms will be in that building or in one of the schoolhouses near by. The hotel headquarters will be at the Genesee House. A special circular in relation to railroads, hotels, and other matters, has been issued by the Local Committee. Arrangements for excursions and receptions will be announced by the Local Committee. The officers of Sections D and H have issued special circulars relating to the meeting, which can be had by addressing the respective secretaries. Special information relating to any of the Sections will be furnished by their officers. In Section E special attention will be given to the problems connected with the Niagara Falls and its gorge.

WE have only just received the *Proceedings* of the American Association for the Advancement of Science at the Philadelphia meeting of 1884. The volume is particularly well printed and fully illustrated.

THE Institution of Naval Architects is holding a summer meeting at Liverpool this week.

THE recent elections have done nothing to alter the comparatively small but distinguished band of men of science in the House of Commons. Sir John Lubbock retains his seat for London University. The electors of South Manchester have remained faithful to Sir Henry Roscoe, and those of South Leeds to Sir Lyon Playfair. Mr. Story-Maskelyne returns from North Wiltshire, and Sir Edward Reed, after one of the principal contests of the election, from Cardiff.

M. JANSSEN is continuing, at Meudon, his researches on the influence of gases on the rays of the spectrum. He is building tubes, which can be loaded with 1000 atmospheres of hydrogen, oxygen, or carbonic acid. In this last case the real density of the gas will be superior to the density of water. The filling of the tubes to these high pressures is not directly obtained by pressure; they are loaded by a sort of step-by-step or cascade process. This is a very long affair. After the filling of these tubes some time must be allowed for the settling down of the dust which has been raised by compression. As long as the cloud of minute particles is floating, the colour of the light traversing longitudinally the tubes is blood-red. This effect can be shown with a far lessened pressure.

MR. J. M. HORSBURGH has been appointed Secretary of University College, London, to enter upon his duties on October 1.

DURING the last ten years M. Marcel Deprez has been engaged in experiments connected with the transmission of force by means of electricity. The Rothschilds some time since provided him with an unlimited credit to prosecute his researches at Creil, under the inspection of a commission of thirty-eight men of science. On Friday the commission met to hear a report on the results at present obtained, drawn up at their request by M. Maurice Lévy. This report was unanimously approved. It appears from it that we can now, with only one generator and only one receiver, transport to a distance of about 35 miles a force capable of being used for industrial purposes of 52-horse power, with a yield of 45 per cent., without exceeding a current of 10 ampères. When the amount of force absorbed by the apparatus used to facilitate the recent experiment, but not required in the applications to industrial purposes, is added, the yield will be nearly 50 per cent. The commission certifies that the machines now work regularly and continuously. The maximum electromotive force is 6290 volts. Before the construction of the Marcel Deprez apparatus the maximum force did not exceed 2000 volts. The report states that this high tension does not give rise to any danger, and that no accident has occurred during the past six months. The commission is of opinion that the transmitting wire may be left uncovered on poles provided it be placed beyond the reach of the hand. It estimates at nearly 5000*l.* the probable cost of the transmission of 50-horse power round a circular line of about 70 miles. This price would, however, be much diminished if the machines were frequently constructed. The commission, in the name of science and industry, warmly congratulated M. Deprez on the admirable results which he had obtained, and expressed thanks to the Rothschilds for the generous aid extended to the undertaking.

THE eighth congress of the French Geographical Societies will meet at Nantes on the 4th proximo, and will continue until the 9th.

IT is stated that Baron de Miklouho-Maclay is now busy getting printed at St. Petersburg, by command of the Czar, the result of his scientific researches in New Guinea from 1870 to 1883.

A CONFERENCE was held by the National Fish Culture Association on Monday last at the Colonial and Indian Exhibition. Sir Albert K. Rollit, M.P., presided. The chairman, in delivering the presidential address, stated that the Association had made a great impression upon the public as to the necessity for remedial, protective, and other measures in the interest of our fishing industries and population. The Association was doing work which many other nations and colonies thought it expedient and economical to do upon a much larger and more expensive scale. He therefore thought the public ought to support it liberally in order to enable it to carry out the work which could